Drop Zone! Design and Test a Probe

The Huygens probe is installed on Cassini.

LESSON TIME

About 6 hours over 4 days; extensions vary

MATERIALS CHECKLIST

For the teacher:

- *Stopwatches (2–3); calculators; hula hoop or sidewalk chalk*
- *Optional: small inflatable wading pool*
- *Optional overhead transparency: "Saturn Discovery Log Writing Prompts" handout*

For the students:

- *Parachuting Probe Packets (one per student or per team)*
- *Lessons 5 and 8 Titan and Huygens material*
- *Parachute construction materials (see Teacher Preparation)*
- *"Saturn Discovery Log Writing Prompts" handout*
- *Saturn Discovery Logs*

TO SEE EXAMPLES OF STUDENT WORK, CLICK HERE

LESSON NO. 9

- *Language Arts Focus — Writing to Plan, Problem-Solve, and Analyze*
- *Science Focus — Designing and Testing a Parachuting Probe*

OVERVIEW

Students are invited to participate in a challenge activity. Using the information learned in previous lessons, combined with their own creativity and problem-solving skills, students design and test a parachuting probe that will withstand a fall from a high point, land intact, be able to descend slowly, float in liquid, and cost the least to launch into space. Extensions provide an option if the teacher has limited time, and invite the students to simulate other experiments that will be carried out by the Huygens probe.

WHY THIS WORKS

Using notes, teaching passages, and any other research or data, as well as a materials list, students design, build, and test parachuting probes. Students justify their design decisions and draw a model of the probe they plan to build. In this way, they have the opportunity to engage in problem-solving, spacecraft design, and experimenting — just like real scientists and engineers. Students might work individually, in teams of two or three, or even complete the parachute activity at home as a family project.

At this point, students have sufficient background information about Titan and the Huygens probe to apply this knowledge to their own experiments. It isn't enough for students to read about science; they also need to *do* science. In the book *Classroom Instruction That Works: Research-Based Strategies for Increasing Student Achievement* (Marzano et al.), the authors assert that scientific inquiry is one of the most important skills for students to have. These lessons provide opportunities and invitations for students to integrate reading, writing, and experimenting. Writing provides a vehicle for student learning throughout this lesson.

Objectives

Students will:

- Demonstrate comprehension by including data from reading in experimental design and developing a persuasive writing piece.
- Design, build, and test a 3-dimensional model of a parachuting probe.
- Consider real-world challenges in their probe designs: speed of descent, ability to land upright, ability to hit a target on the ground, and ability to float in liquid.

- Use Saturn Discovery Log writing to help them think through a problem as well as document a process.
- Document their designs using illustration with text.
- Use exposition to write a Report of Findings about their design/experiment.
- Use science inquiry skills: developing investigatable questions, carrying out fair testing, hypothesizing, and drawing conclusions based on evidence.

teacher TIP

Allow sufficient time for copying, compiling, and stapling the probe packets (20 minutes or more) and to set up construction materials for the probes or parachutes. This is a great parent volunteer opportunity.

Teacher Preparation

- Print out and photocopy, one per student or one per team, student handout 1, "Parachuting Probe Packets" (4 pages). Photocopy the pages back-to-back, nest the pages, and fold (check to make sure the pages are in order). Staple into booklets (5-1/2 by 8-1/2 inch) using a long-arm stapler.
- Print out student handout 2, "Saturn Discovery Log Writing Prompts" and make a copy for each student. Optional: make an overhead for class discussion.
- Parachute materials:

  —14 by 14 inch sheet of sturdy plastic material (cut from garbage bags)

  —Several large sheets of plastic to be cut into various sizes

  —Mylar®

  —Pre-cut set of four 14-inch strings per student or team

  —Plenty of additional (uncut) string for adaptations/variations

  —Masking tape; clear tape; hole punch; self-adhesive, 1/4-inch hole reinforcements

  —Optional: metal washers for weights if you want to do an investigation using parachutes alone either before, or in lieu of, building the probes. Paper napkins or tissue paper can be used for simple parachutes.
- Probe materials (whatever you can scavenge and/or students can bring in):

  —Paper cups/plates of various sizes; cleaned pint-size milk cartons; paper cylinders (e.g., paper towel or toilet paper tubes)

  —Pipe cleaners; foil; corks; straws; tissue paper; Mylar®; popsicle sticks; tape; stapler; nylon stockings/pantyhose

  —Optional: materials for decoration

A Note on Materials Management

The amount and type of materials that you gather will determine whether or not students may have "unlimited" amounts of the available supplies, or if you need to evenly distribute what you have. You can set "prices" on the materials, and give students a budget or limited amount they can spend. You can also provide all students with a basic set of supplies (four pieces of string, a piece of plastic, etc.), and give them a budget with which to purchase any extras.

What to Do

Preliminary (Optional) — Experiment with Simple Parachutes

1. Follow these instructions, or see the parachute lesson in the book *Science on a Shoestring* by Herb Strongin.
2. For the parachute, use tissue paper or paper napkins (approximately 14 inches square). Use a paper punch to make one hole in each of the four corners, and strengthen with a self-adhesive binder paper hole reinforcer (available at office supply stores).
3. Attach 14-inch lengths of kite string to each corner, and tie these to a small washer (inexpensive, readily available in hardware stores).
4. Students need to figure out how to fold and toss the chutes so that they open and how to slow the fall of the washer. Once students have mastered these, they can experiment with different lengths of string, different-size washers, and/or different parachute materials. Be sure they understand that they should only change one variable at a time in order to have a "fair" test!

teacher TIP

- Have students experiment with simple parachutes before experimenting with parachuting probes.
- Instead of building the probes during class, have students build their probes as a family project at home and use class time for testing and writing.

Day One

Introduction to the Challenge; Planning Time — Suggested time 1–2 hours

1. Introduce the lesson by telling students that they now have the opportunity to put themselves in the shoes of spacecraft designers and engineers.
2. Distribute the Parachuting Probe Packets and read the text aloud.
3. Ask for questions, and have the students summarize the activity aloud. Record their retelling as a "to do" list on the board or on an overhead transparency.
4. Show the students the materials that will be available for them to use for building the probes.
5. Monitor student progress. Circulate among teams as the students name their probes, complete their plans, and record information in their Parachuting Probe Packets.

Sharing Out — Suggested time 20 minutes

1. Have individuals or teams share their plans with the whole class.
2. Have the students who are not presenting listen for ways that their plans are similar to, and different from, their peers' plans. Allow time for questions and answers among the students.

Day Two

Constructing the Probes — Suggested time 1–2 hours

1. Have materials available for probe construction. Direct students to select materials and construct probes.
2. Provide time for students to share their designs with one another, and the whole class. Each design team can explain their choices and designs BEFORE testing begins. Students can summarize and justify design decisions, both orally and in writing (in their Saturn Discovery Logs).

Day Three

Testing the Probes — Suggested time 1–2 hours

1. Set up a testing area. Enlist the help of an adult volunteer, such as the school custodian. You will need to get a ladder so your volunteer can climb to the roof, or other high spot (e.g., bleachers) at your location. If your school does not have a suitable "drop zone," you may want to visit a nearby high school.
2. Draw a "target" on the playground with sidewalk chalk below the drop site, or, if it is not windy, use a hula hoop.
3. If you have access to a small portable wading pool, use this for the landing in liquid test. (Be sure the students understand that there will not be liquid water on Titan's surface, though there may be liquid of a different type.)
4. Discuss "fair testing" with the students.
5. Decide on a fair way to select who goes first. Try this: print students' names on ice-cream or popsicle sticks for random selection of names.
6. You will need to figure a baseline time of descent from your drop point. To do this, drop an object that does not have a parachute attached — for example, a clay ball — and record the descent time. Then set a reasonable target time *slower* than the clay ball's descent time for the students to try to meet. Have students add their test data to their Parachuting Probe Packets.
7. One person (an adult volunteer) should be the "dropper." The dropper should try to drop the probes in the same manner each time. If possible, have two or three students timing the descent of each probe, and average the times. Also, if possible, there should be three trials for each probe — the test page in the Parachuting Probe Packets is set up for three trials.
8. Have students write their observations of their classmates' experiments in their Saturn Discovery Logs. This will help them in recalling this information during the whole-class discussion. It also reinforces the idea that the classroom is a community of learners, and that we learn from one another.

Day Four

Discussing Results — Suggested time 45 minutes to 1 hour

1. Begin with a whole-class discussion. Students can share observations, questions, and hypotheses that they have recorded in their Parachuting Probe Packets or their Saturn Discovery Logs.
2. Ask the following questions, and record student responses on the board or on chart paper:
   - Which designs or design elements seemed the most stable, or added stability?
   - Which parachutes seemed to take the longest to land?
   - Which designs or design elements seemed to hit the target, or closest to the target, most often?
   - Is there an optimum weight the probe needs to be in order to land accurately?
   - Is there a relationship between parachute size and probe weight?

Analysis, Re-Design, Re-Test — Suggested time 45 minutes to 1 hour

1. Here is where students refine their designs through analysis and conclusions.
2. Students can make modifications as recorded in their Parachuting Probe Packets.
3. If there is time, students can re-test their modified designs.

Using Writing as a Tool For Reflection — The "Report of Findings"

1. Give a copy of the student handout "Saturn Discovery Log Writing Prompts" to each student. You may wish to use an overhead transparency for class discussion.
2. Have students discuss the questions with their partners or group before writing their responses in their Saturn Discovery Logs.

Extensions

Special thanks to Dr. Jean-Pierre Lebreton and Dr. Ralph Lorenz, Cassini mission scientists, for the extension activities offered here.

1. Parachute Inquiry. If you have limited time, you may want to have students conduct a parachute inquiry only. This is an easy modification, and the questions in the Parachuting Probe Packet can be applied to parachutes rather than probes. You can still design/re-design for landing within a target area, and determine which parachute takes the longest time to descend. Metal washers (available at hardware stores) can be used as weights. It will still be important to discuss "fair testing" with the students. For example, if they change parachute material, string length and washer size/weight should be kept constant. If they change washer size/weight, string length and parachute size/material should be kept constant.
2. Optimization Exercise. Students can experiment with parachuting paper or cardstock cone-shaped "shields." A broad cone gives more drag (slows you down more); while a narrow cone is more stable, given the same amount of material. Students can first measure the time it takes a washer or ball of clay to fall from a given height (e.g., roof of the building). Parachuting shields earn points based on how much more slowly they fall. They also earn points for stability — specifically for how close they fall to a target drawn on the ground. Points can be "charged" for how much material is used to construct the shields. There should be some optimum where the cone is sharp enough to fall in a stable fashion and to land close to the target, but not so sharp it needs lots of material to have enough drag.
3. Characterizing an Unknown Surface. One of the Huygens probe's responsibilities is to characterize the surface of Titan from the impact as recorded with onboard accelerometers. You can model this in the classroom by creating different surfaces hidden inside cardboard boxes: for example, sand, gravel, brick, and water. Students can make a hole in the box top, and drop a "probe" (marble) into the hole at the top of the box, and try to guess what the surface is from the sound it makes. If a teacher had a microphone/computer hook up, students could even "look" at the sound.

Assessment

Questions in the Parachuting Probe Packet invite students to reflect and self-assess. Teacher observation of student behavior during the activity, as well as students' written work, can be used to assess understanding of both writing and science.

As you look at the students' writing, ask yourself the following questions:

1. Are the questions they ask investigatable?
2. Is the experimental plan clear and sequential?
3. Has the data been recorded in an organized way?
4. Does the writing show evidence of the student's reasoning from evidence?
5. Does the reflective writing show evidence of critical and creative thought?

Standards

National Council of Teachers of English and International Reading Association Standards for the English Language Arts

All students must have opportunities to:

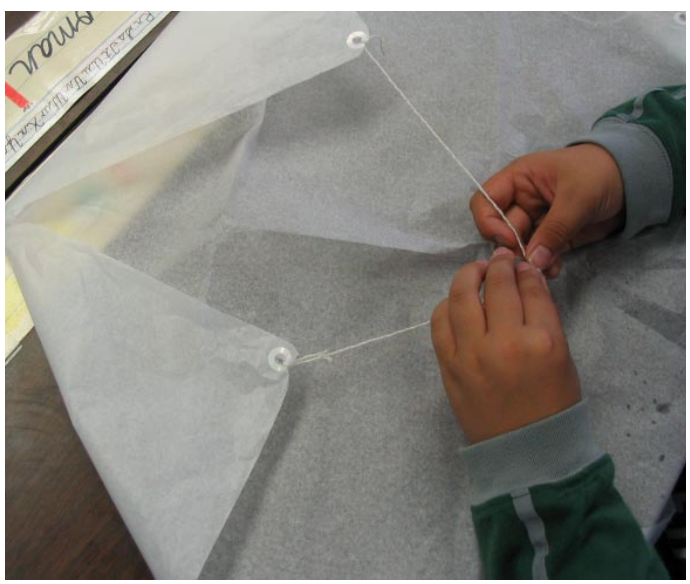
- Participate as knowledgeable, reflective, creative, and critical members of a variety of literacy communities.
- Employ a wide range of strategies as they write and use different writing process elements appropriate to communicate with different audiences for a variety of purposes.
- Use spoken, written, and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information).

National Science Education Standards

As a result of their activities in grades K–4, all students should develop:

- Abilities necessary to do scientific inquiry (Science as Inquiry) and understandings about scientific inquiry (students plan and conduct a simple investigation).
- Abilities of technological design (Science and Technology), and understandings about science and technology (students communicate a problem, design, and solution).

Examples of Student Work



Building parachutes

Saturn Discovery Log Writing Prompts

In what ways did your design meet the criteria?

What were some challenges you encountered, and how did you solve them?

What changes would you like to make in your design? Why?

What are you most proud of?

What questions do you still have?

What do you like best about being a spacecraft engineer?

What do you think are the biggest challenges of being a spacecraft engineer?

What would you like to ask the Cassini–Huygens engineers?

What would you like to ask the Cassini–Huygens scientists?

Questions for the Spacecraft Engineers

1. What did you find most surprising or interesting?

2. What problems did you encounter as you built and/or tested your probe? What changes did you make, and why?

3. Based on your trials, and observations of your classmates' designs and tests, what changes, if any, would you make to your design?

4. What questions do you have now?

5. What questions would you like to ask of the Huygens Design Team?

6. What would you like to try next? Why?

Parachuting Probe Packet

The ____________________ Probe

Design Team/Spacecraft Engineers

____

____

Date____________________________

Engineering and Design Team Challenge:

Design a parachuting probe that will land upright on both solid and liquid surfaces, remain intact (not break apart), weigh as little as possible (while still meeting the other criteria), and meet the requirements for time of descent (how long it takes the parachute to land after being dropped).

Background information for Design Team:

Spacecraft engineers face many challenges. They design machines that survive the forces of being launched into outer space and operate there with little assistance from Earth.

Once in space, the spacecraft must protect its delicate instruments throughout the journey. We are counting on Cassini to protect Huygens on its seven-year journey from Earth to Saturn.

Any heat absorbed or produced by the spacecraft must be managed to prevent the instruments from overheating or getting too cold. The probe must be strongly anchored to the spacecraft, yet able to separate in a controlled fashion at the right time. Both spacecraft and probe must be protected from dangerous radiation and from high-speed dust particles.

The probe must remain able to operate after many months or even years of inactivity. It must also be able to respond to commands and to radio its data back to Earth as accurately as possible.

Testing the ________________________________Probe

Trial Number	Condition Upon Landing	Time of Descent	Notes, Observations, Questions
1			
2			
3			

Idea 3 — Final Plan (draw and write):

Weight of Probe:

Your Task:

You will design and build a parachuting probe. Given an assortment of materials commonly found at home or in the classroom, you will construct a parachuting structure that will:

1. Land upright on a solid or liquid surface. (To simulate the requirement for the Huygens instruments — camera and other instruments — to be able to take pictures and measurements)

2. Land undamaged. (To simulate the requirement for the instruments to be able to work — they must not break on impact.)

3. Take as long as possible to land, but land within in a designated area. (Huygens' parachute size will control its descent time. Huygens will be collecting data as it descends.)

4. Weigh as little as possible. (A fourth property to consider is weight. The more a spacecraft weighs, the more it costs to launch it and maneuver it in space. So, you want your probe to be as light as possible.)

Imagine the possibilities! Wonder! Create!

Helpful Science Hints

Scientists use the word “impulse” to describe an impact.

Impulse is the force of impact multiplied by the amount of time the force is exerted. There are two types of impulse: hard and fast, and soft and slow. Hard and fast is usually not the way you would like to experience a change in speed. That’s when you run into a brick wall at full speed, going from fast to stopped in a fraction of a second. The great amount of force you experience over the short amount of time can result in broken bones, or worse. So, soft and slow is the way to go.

If the wall you run into is padded like a mattress, you will enjoy the result more than if you run into bricks. To give your probe the best chance for survival, you need to think about how to give it the soft and slow type of impulse. Anything you can do to increase the amount of time the probe spends slowing down before hitting the ground will increase its chances of landing intact.

Your parachute will be central in this endeavor. You may want to do some initial experimenting with parachutes. Think about these questions:

• What happens if you change the size of the parachute?

• What happens if you change the length of the strings that attach the parachute to its load?

• What happens if the parachute is attached in different places?

Idea 1 (draw and write):

Idea 2 (draw and write):